3. History of agriculture. (*a*) Kind of country suitable for farmers; compare with pasture lands; necessity for fertile soil; picture a river valley, the river used as a means of communication. (*b*) Food: methods of obtaining food with primitive tools; history of the plow and other agricultural implements; history of the mill; early methods of cooking; making pottery; stories of famous potters and stories from the decorations of Greek vases. (*c*) Shelter: permament homes; beginnings of architecture; forms of stone houses; forms of brick constructions; homes of other lands. (*d*) Social organization: individual family; ownership of property; the homestead: the pasture; the arable land; beginning of cities.

4. Civics: study of methods of transportation; stories of great sailors and explorers.

REFERENCES: Heck, "Agricultural Machinery," *Iconographic Encyclopædia*, Vol. VI, p. 177, plates 1–8, 56–60; Small and Vincent, "The Family on the Farm," *An Introduction to the Study of Society;* Knight, *Mechanical Dictionary;* Abbott, *Primitive Industry;* "A Visit to a Wheat Farm," *Carpenter's Geographical Reader, North America*, p. 164; Parker, *Uncle Robert's Geography*, Vol. II, chaps. vii, viii, x; Chase and Clow, *Stories of Industry*, Vol. II, p. 92; *Baldwin's Fourth Reader* (Haymaking), pp. 55–62; Binns, *The Story of the Potter;* Payne, *History of America*, Vol. I; Viollet-le-Duc, *Homes and Habitations of Man in All Ages;* Regozin, *Chaldæa;* Voorhees, *First Principles of Agriculture;* Keary, *Dawn of History*, chap. viii; Starr, *Some First Steps in Human Progress;* Smith, *Ancient History of the East* (Egypt); Wilkinson, *Ancient Egyptians*, Vol. II, pp. 377–429; Rawlinson, *Ancient Monarchies*, Vol. I (Chaldæa); Morris, *The Aryan Race;* Hearn, "The Aryan Family;" *Britannica*, article on Architecture; *Journal of the Anthroprological Institute;* Butterworth, *The Growth of Industrial Art.*

APPLIED MATHEMATICS.

GEORGE W. MYERS.

ELEMENTARY MATHEMATICS IN ASTRONOMY.

WHEN it is admitted that the study of geography should begin with a study of the pupil's environment, it should not be forgotten that environment is not determined solely from proximity of place. Many of the most important facts and teachings commonly included under the heading geography cannot be understood in any other than a merely verbal way without an appeal to phenomena usually thought of as being too remote from the pupil to constitute a part of his environment. If by environment we mean, as we should, whatever lies so closely within the range of the pupil's senses as to make a direct appeal to his

consciousness, we must include in elementary geographical work a study of the more obvious phenomena of the sky.

The only satisfactory way to impress a pupil with the earth's form and movements is to direct his attention to the changes on the sky which are due to these facts and which are spread out before him at just the time he can best afford to study them. Such phenomena as the rising and setting of the stars, the gradual slipping of the constellations toward the westward as the seasons come and go, the shifting of the positions of the moon and brighter planets among the stars from night to night and from week to week, are continually before his eyes, and would arouse a world of thought and inquiry within him, if he could be guided a little here and there until he learns *what* and *how* to observe. The mental soil thus created will be found to be fertile for the contemporaneous or later teachings and interpretations of geography, while, at the same time, he is acquainting himself with a field unequaled for the number, range, and variety of opportunities for scientific verifications and interpretations that will be of lifelong interest and benefit to him.

Many object to such work, thinking that it is too difficult for the elementary pupil. This objection is, we have noticed, usually urged on theoretical grounds, or by those who have never undertaken to do such work themselves. It should be said, however, that the difficulty will be great or small, pretty much as the teacher makes it. But quantitative accuracy is not the object to be attained. For example, in the study of the constellations, only a few (two or three) stars in each, should be attended to at first, unless they fall into simple figures, and then, at first, only these figures. Moreover, *not too much* memorizing of names and mythological lore should be indulged in.

The object of the work is a first-hand familiarity with *what* actually takes place and *how* it takes place. So far as the pupil himself raises a question as to the reason for the observed occurrence, he should be led to look for the reason in his notes. Occasional suggestive questions from the teacher, not too many, may be helpful. But just here the German pedagogical maxim, "Never tell the pupil anything," may easily be overdone. It

should be construed to mean, "Never tell the pupil anything he can discover for himself in a reasonable time from the facts he has." This does not have the epigrammatic ring of certainty and finality of the terser form of statement; but it is far less dangerous in the hands of the average teacher.

The aim of the outline which follows for this month is to acquaint elementary and secondary teachers with the part of the sky needed to study the planetary and lunar movements; to explain such questions as the form, rotation, and revolution of the earth, day and night, changes of the seasons, etc., which arise early in the geography.

I. Using the sketches on the board, identify from your homes:

1. The dipper in the Great Bear (Ursa Major).

2. Polaris and dipper in Lesser Bear (Ursa Minor).

3. Cassiopeia's Chair (use the imperfect W).

4. Lyra by triangle and parallelogram.

5. Scorpia, by Antares and starry arch.

6. Sagittarius, by inverted dipper.

7. Carefully plot the two very bright objects in this constellation with reference to the surrounding stars. How far apart are they in degrees? Continue this at intervals of a few days during the quarter.

8. Undertake to identify, with the teacher's aid, the constellations on the eastern horizon as soon after sunset as possible. Repeat this from month to month.

II. Discussion of the foregoing observations.

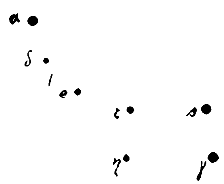
III. Return to the dipper in Ursa Minor for standards of stellar brightness. Fix this figure in mind so firmly as to be able to find it readily in any position. For purposes of comparison and description stars are distinguished in the following obvious particulars: (1) as to brightness, (2) as to color, (3) as to steadiness of light, (4) as to their diurnal movements.

1. Astronomers group the 14 brightest stars in the sky into a class by themselves and call them *first magnitude* stars. The next 50 are said to be of the *second magnitude* class. The next 150 constitute the *third magnitude* class; the next 315, the *fourth;* the next 850, the *fifth;* and all the fainter ones, still within reach of the naked eye — about 2,000 of them — make up the *sixth magnitude* class.

It is important to obtain a notion of the brightness of a first, second, etc., magnitude star with sufficient definiteness to enable one to decide at once to which class a given star belongs. To do this it is necessary to have in mind certain type stars of the various classes. The beginner may then refer to these standards and will have little difficulty in making up his mind as to which standard a given star stands nearest in brightness.

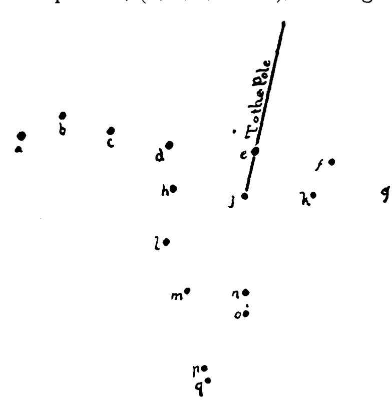
Vega, Capella, Arcturus, Antares, Aldebaran, Altair, Betelgeuse, Rigel, Regulus, Procyon, Sirius, some one or more of which can always be found, may serve to furnish an idea of the brightness of first-magnitude stars. Vega, Arcturus, and Procyon are good standards.

For the remaining classes it will be best to make use of the dipper in Ursa Minor. The star marked α (alpha) in the adjoining group is Polaris, which with β (beta) will furnish standards for second-magnitude stars. Star γ (gamma) is a typical third-magnitude star. Beta and Gamma are the guards of the pole. Delta (δ), Epsilon (ε), and Zeta (ζ) are of the fourth, and Eta (η) is of the fifth magnitude. Any star fainter than the fifth magnitude, and still visible to the unaided eye, is of the sixth magnitude.



With a little practice, a student can readily distinguish smaller gradations of brightness than half magnitudes. He is soon able to do better than this. A star lying in brightness about midway between the typical first- and second-magnitude stars is said to be of the 1.5 magnitude. So also we have stars of the 2.5, 3.5, 4.5, etc., magnitudes. And so, if the light of a star seems to be about half-way between a 2.5 and a third-magnitude star, it is said to be of the 2.7 or 2.8 magnitude, etc.

Exercise.—(*a*) Arrange the seven stars of the dipper in Ursa Major into an orderly sequence, the brightest coming first, the next second, etc. Designate the stars by the letters of the Latin alphabet, (*a*, *b*, *c*, ...), *a* being the star at the remote end of the handle, *b* the next, etc., for purposes of clearness of record. Or write the magnitude number beside the star in a rough, though legible, sketch. (*b*) Attach magnitude numbers (by estimate) to all the stars in the accompanying sketch.



2. The stars differ very markedly among each other in color. For example, Antares and Aldebaran are *red* stars; Capella is white; Vega, blue; Arcturus, yellow; etc. Estimate and record the colors of the individual stars of the groups studied above. Does the same star always seem of the same color? Estimate the colors of the visible planets in terms of star colors. Does the opera glass seem to affect the color of a star viewed through it? How?

The following numerical color scale is in use among astronomers: 0, pure white; 1, bluish to yellowish white; 2, yellowish white; 3, yellowish; 4, pure

yellow; 5, straw yellow; 6, orange; 7, golden yellow; 8, reddish; 9, copper red; 10, pure red.

Which of the numbers of this scale most nearly applies to each of the stars in the groups studied above?

3. As to steadiness of light there are also great differences among stars. To bring this fact out, make a protracted comparison of Algol, β Lyræ, or Mira with other bright stars about them. Can you prove a variation of their light from your observations?

IV. To find the law connecting the distance of the observer with the apparent size of an object. (See Experiment VII, *Elementary Experiments in Observational Astronomy.*) (1) By measures of angular dimensions and of the distances of a globe or other object with the plane-table. (2) Same with the home-made transit. (3) Discuss and bring out the law indicated by your measures. (4) What mathematical ideas have you used?

V. Map the outline of a field, or pond, and locate any permanent objects upon it. Use the plane-table and home-made stadia (Experiment VIII). (1) Construction of apparatus. (2) Execute the field work. (3) Discuss and plot your data. (4) Mathematical ideas and operations used.

VI. To find the angular value of the diameter (roughly) of the moon or sun. (1) By means of a graduated lead pencil, held at arm's length. (2) By a stick placed some twenty feet from the eye. (3) By a movable sight carried along a graduated bar. (4) Check by sextant measures.

NOTE.—To observe the sun use a piece of smoked glass.

VII. From the above data and the law connecting distance with diameter (*vide* Topic IV), work out the diameters of sun and moon, supposing the sun's distance to be 93,000,000 miles and the moon's 240,000 miles.

VII. Lectures: (1) Planetary and lunar motions, with lantern slides. (2) Stars and star clusters (illustrated). (3) Tides.

VIII. Number aspects of these lectures. (1) Where should such work be put in the curriculum of the elementary school? (2) What should be its relation to the geography? to the nature study? (3) To what extent can it and should it be carried? (4) What sort of number work does it represent?

IX. Write a plan for teaching some subject covered in the foregoing outline to the grade to which you think it best suited.

X. Number aspects of foregoing work. Discuss the measures and numerical ideas involved in carrying out the foregoing outlines with reference to the following syllabus on measurement. Measurement of limited magnitude. (1) With an individual (qualitative unit). (*a*) Direct measurement (counting). (*b*) Indirect measurement (valuation). (2) With a quantitative unit. (*a*) Direct measurement (number). (*b*) Indirect measurement: (α) through relations to a unit of like kind; (β) through relations to a unit of unlike kind.

XI. Measurement of number. (1) Always with quantitative unit. (*a*) Direct measurement; (*b*) indirect measurement; units always of like kind.

APPLIED ARTS.

DECORATIVE PAINTING.

JOHN DUNCAN.

LAST month we gave a general sketch of the work we have planned for the afternoon, and we now give a short account of the process of stencil-cutting which we are to employ in its execution.

This is a craft that requires only the simplest tools. With a sheet of glass, a pocket knife, an oil stone, a drop of linseed oil and one of varnish, a piece of paper, a stencil brush, and a little calcimine color, we are equipped for our work.

Any country teacher, armed with this simple apparatus, a very little artistic skill, and a great deal of taste, can set about the decoration of her schoolroom with the happiest auguries of a successful issue to her labors.

There is all the difference in the world between a stencil made by a perfunctory house painter—and most of them, alas, come under this description—and a stencil made by one who makes it for the joy of it.

The process is as follows:

First the design is drawn out. Then the artist decides how many stencils will be employed to produce the desired effect. Say we use three, as in the accompanying illustration, Plate III.

The whole surface to be covered by the design may be laid in with a light color—in our illustration this is represented by the white paper.

The background, a color let in, is planned so as to allow the light ground color to show all around the pattern. Compare figs. 1 and 4.

The outline of this background is traced from the sketch design to a piece of stout cartridge paper. The paper is then washed over on both sides with linseed oil, which is allowed to soak in for an hour or two. The work is then ready for the cutting of the stencil.

It is laid upon a sheet of glass and cut with a sharp-pointed knife—a pocket knife is admirable for the purpose. If the paper has been well saturated with oil, and the knife is kept with a very keen edge (it is, of course,